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Magnetron Sputtering System for Novel Intrinsically Switchable Thin Film Ferroelectric Resonators and Filters, Final REPORT

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5b. GRANT NUMBER

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6. AUTHORS

Amir Mortazawi, Victor Lee

5d. PROJECT NUMBER

5e. TASK NUMBER

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University of Michigan - Ann Arbor
Regents of the University of Michigan
3003 S. State St
Ann Arbor, MI 48109 -1274

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Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

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TOTAL:

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Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Paper

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT SUPPORTED

FTE Equivalent:

Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:	0.00
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The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....	0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):	0.00
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Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT SUPPORTED

FTE Equivalent:

Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

See Attachment.

Technology Transfer

DURIP Final Report

DRDA Number: 10-PAF01589

PAF Title: Magnetron Sputtering System for Novel Intrinsically Switchable Thin Film Ferroelectric Resonators and Filters

PI: Amir Mortazawi

Direct Sponsor: Defense, Department of-Army, Department of the

PGN: F025413

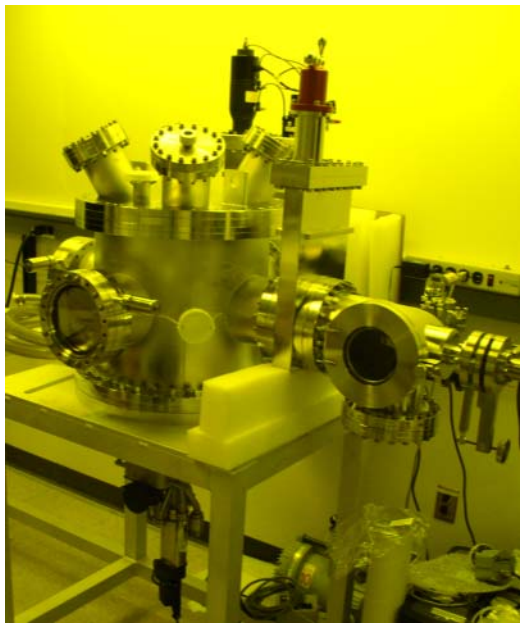

Fig. 1. Assembled RF magnetron sputtering system for the deposition of BST thin films.

RF Magnetron Sputtering System

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Main Processing Chamber

The main processing chamber is a double walled cylindrical stainless steel vessel with a diameter and height of 16” and is where the film deposition occurs. The chamber is cooled by flowing chilled water through the chamber walls. There are three 8” and one 10” CF ports which are separated by 90º on the perimeter of the chamber. The 8” ports are for attached to the load lock and view ports for transferring wafer into and out of the chamber. The 10” port is attached to the 3-position gate valve and the cryogenic pump. The top lid of the chamber has four 6” CF ports and can accommodate a maximum of four sputtering guns. Each sputtering gun is 30º off the vertical axis and points to the exact center of the chamber. The bottom lid is configured with an 8” CF clearance port to accommodate the substrate assembly as well as a 1.33” mini CF flange for the substrate shutter. Several additional 2.75” CF ports are also located on the wall and lid of the chamber for gas management, pressure measurement, etc.

Load Lock and Substrate Assembly

The sputtering system is configured with a load lock and a manual linear motion transfer arm which transfers the wafers to and from the substrate assembly inside of the main processing chamber. The load lock enables the main processing to be maintained under vacuum at all times which helps prevent the introduction of contaminates into the thin film growth environment. The load lock is also configured with an 8” CF port to accommodate a turbomolecular pump, which can be added to the sputtering system at a later time if necessary.

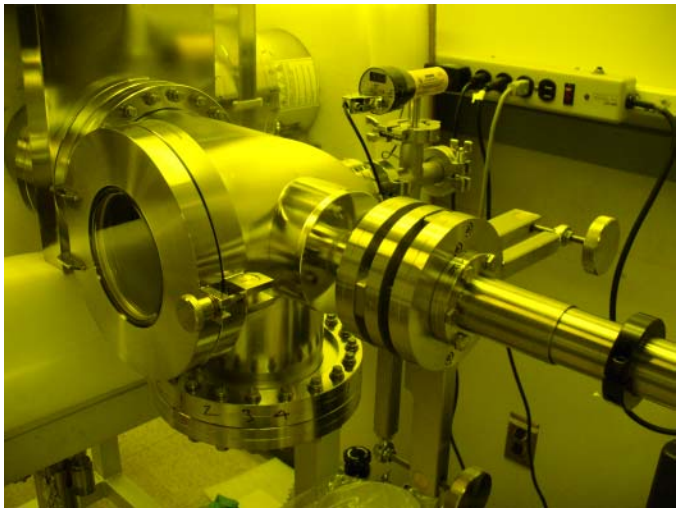

Fig. 2. The load lock for loading and unloading samples to and from the main processing chamber, respectively.

The substrate assembly is designed to be used with wafers up to 4” in diameter and has quartz lamp heaters that can heat the wafers up to 850ºC. In addition, it is connected to an electrical motor that rotates the sample to improve film uniformity. The substrate assembly can be biased up to 100 V to adjust the growth conditions and to improve film quality.

Mechanical Scroll Pump

The sputtering system requires a mechanical scroll pump to bring the load lock and main processing chamber from atmospheric pressure to medium vacuum. This particular type of pump does not expose any part of the vacuum system to any oils, further reducing the possibility of introducing contaminants into the system.

Cryogenic Pump

The sputtering system requires an additional pump to bring the main processing chamber from medium vacuum to ultrahigh vacuum. Cryogenic pumps have no mechanical components and are very robust. they operate by condensing gases onto a cold head which is kept at cryogenic temperatures with the use of a liquid helium compressor. The cryogenic pump is attached to the 10" 3-position gate valve that is attached to the 10" port of the main processing chamber.

RF Magnetron Sputtering Gun

The sputter system has two RF magnetron sputtering guns installed for the deposition of either two distinct target materials or the simultaneous deposition of the same target material for doubling the deposition rate. Each sputtering gun is fed by an RF power supply that can provide up to 300 W of power and is controlled by an automatic matching network for minimizing the reflected power. The sputtering guns can also be used with a DC power supply for depositing metals.

Sputtering Targets

The sputtering system is setup to sputter $Ba_{0.5}Sr_{0.5}TiO_3$ and $BaTiO_3$ thin films. These 4" diameter, 0.25" thick targets have a copper backing plate which is used to help conduct heat away from the target as well as for attaching the target to the RF magnetron sputtering guns

Gas Management and Pressure Measurement

The process gases are managed by a 3-position gate valve, mass flow controllers (MFCs), and pressure sensors. The 3-position gate valve throttles the pumping speed of the cryogenic pump and is used for establishing the medium vacuum process pressure. The two MFCs control the flow of O_2 and Ar into the chamber. Lastly, the pressure sensors measure the chamber pressure and are used to adjust the 3-position gate valve and the MFCs to achieve the desired process pressure.

Water Chiller

The sputter system has a water chiller which cools the main processing chamber, the RF magnetron sputtering guns, the helium compressor that is used for the cryogenic pump, and the substrate assembly. The chiller has a 7.0 kW cooling capacity and is water cooled. It will be connected to facility water circulation system so the heat is not dissipated into the laboratory environment.

Appendix A: List of Vendors

[1] A&N Corporation
707 SW 19th Avenue
Williston, FL 32696
Contact: Ben Bowers, (352) 528-7831
sales@ancorp.com

[2] Thermionics Northwest, Inc.
231-B Otto Street
Port Townsend, Washington 98368
Contact: Tom Beard, (360) 385-7707 Ext. 116
sales@thermionics.com

[3] KURT J. LESKER COMPANY
PO Box 10
1925 Route 51
Clairton, PA 15025-3681
Contact: Matt Belz, (412) 387-9129
salesus@lesker.com

[4] Brooks Automation, Inc.
15 Elizabeth Drive
Chelmsford, MA 01824 U.S.A.
Contact: Kristie Riddle, (978) 262-5701

[5] MeiVac Inc.
5830 Hellyer Avenue
San Jose, CA 95138
Contact: Todd Johnson, (408) 362-1000 Ext. 376
support@meivac.com

[6] HVA, LLC
12880 Moya Blvd
Reno, NV 89506-2611
Contact: Trevor Murri, (775) 359-4442 Ext. 237
sales@highvac.com

[7] Blackhawk Machinery & Systems, Inc.
1471 Blackhawk Drive
Mount Prospect, Illinois 60056
Contact: David Ennes, (847) 427-0414